



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : H04Q 7/00	A1	(11) International Publication Number: WO 91/02435 (43) International Publication Date: 21 February 1991 (21.02.91)
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(21) International Application Number: PCT/US90/04141

(22) International Filing Date: 23 July 1990 (23.07.90)

(30) Priority data:
389,723 3 August 1989 (03.08.89) US

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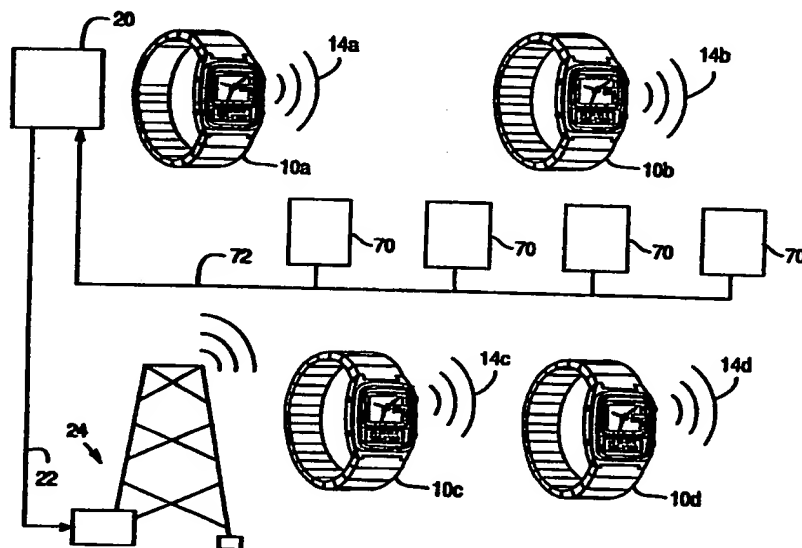
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(81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent)*, DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent).

Published*With international search report.**Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.*

(54) Title: ANSWER-BACK PAGER



(57) Abstract

A paging system broadcasts a message to a selected remote pager at a known broadcast time. The selected remote pager transmits an acknowledge signal (84) following a predetermined delay relative to the broadcast time. The paging system verifies receipt of the message by offsetting the time of receiving the acknowledge signal with the predetermined delay (146), thereby deriving the broadcast time and associating the acknowledge signal with the selected remote pager (150). The remote pager broadcasts a low wattage acknowledge signal to conserve power and the paging system includes a network of acknowledge signal receivers distributed through the paging area for reporting times at which acknowledge signals occur within the paging area.

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ANSWER-BACK PAGER2 Field of the Invention

3 The present invention relates to paging systems and, more
4 particularly, to a paging system employing answer-back
5 pagers for acknowledging receipt of message data.

6 Background of the Invention

7 Paging systems that employ one or more broadcast stations
8 and a number of remote pager units located within a
9 paging area are well know. Most remote pager units are
10 small portable devices carried by individuals. Such
11 pagers carry a battery power source requiring replacement
12 or recharge. Accordingly, a major consideration with
13 respect to pagers is power consumption.

14 Pagers that provide an acknowledgement signal when a
15 message is received are known. Such systems can verify
16 that a message has been received by the proper pager. In
17 the known systems, such verification is achieved by
18 transmission of a radio frequency acknowledge signal from
19 the pager. Pagers that provide an acknowledgement are
20 desirable because a pager may be outside the paging area,
21 turned off, or unable to receive message data due to
22 signal interference. The absence of an acknowledge
23 signal from a pager may trigger retransmission of a
24 message or other remedial action.

1 The prior art shows the use dedicated frequency subbands
2 for transmitting acknowledge signals. In such systems a
3 number of frequency subbands are required in order to
4 provide answer-back capability, and unavoidable
5 competition for these frequency subbands exists.

6 In U.S. Patent No. 4,713,808, issued December 15, 1987 to
7 Gaskill, et al., pager power consumption is minimized by
8 providing a transmission protocol wherein individual
9 pagers activate during predetermined associated time
10 slots and monitor a selected one of several broadcast
11 stations, or frequencies, for message data. The one or
12 several broadcast stations are programmed to broadcast
13 message data for a pager only during time slots
14 associated with that remote pager. In such a system the
15 pagers, being active only during brief time periods,
16 conserve power, yet reliably receive message data. To
17 insure that each pager receives its message data, message
18 data is rebroadcast a number of times with the
19 expectation that eventually the remote pager will receive
20 the message data. The Gaskill system would benefit by
21 use of an acknowledge signal in that once a pager
22 provides an acknowledge signal relative to a given
23 message, there is no need to rebroadcast the message.

24 Unfortunately, known methods of broadcasting acknowledge
25 signals from pagers are unsatisfactory due to the number

1 of dedicated frequency subbands or the amount of power
2 required.

3 Objects and Advantages of the Invention

4 It is an object of the present invention to provide a low
5 power consumption pager with message acknowledge
6 capability. Such a pager would have a long battery life
7 while providing message verification.

8 It is a further object of the present invention to avoid
9 use of multiple dedicated frequency subbands for
10 acknowledge signals. By avoiding multiple dedicated
11 frequency subbands for acknowledge signals, only a single
12 acknowledge signal frequency subband is required, yet no
13 competition for the acknowledge signal frequency subband
14 exists.

15 It is yet a further object of the present invention to
16 avoid redundant message transmission after a pager has
17 received a message. By providing an acknowledge signal,
18 redundant message transmission is avoided and subsequent
19 time slots, otherwise used for redundant message data,
20 are available for new message data.

21 Summary of the Invention

22 The foregoing objects and advantages are achieved by a
23 paging system broadcasting a message to a selected remote

1 pager at a known broadcast time. The selected pager
2 transmits an acknowledge signal following a known delay
3 relative to the broadcast time. The paging system
4 verifies receipt of the message by offsetting the time of
5 receiving the acknowledge signal with the known delay,
6 thereby deriving the known broadcast time and associating
7 the acknowledge signal with the selected pager.

8 In a principle embodiment of the present invention,
9 message data is broadcast to a selected pager during a
10 predetermined time slot associated with the selected
11 pager. Each pager activates during its associated time
12 slot to receive message data. In the event that message
13 data is received during a given time slot, the pager
14 transmits an acknowledge signal following a predetermined
15 delay relative to the given time slot. The paging system
16 thereby associates the acknowledge signal with a given
17 pager by offsetting the time of receiving the acknowledge
18 signal by the predetermined delay to derive the time slot
19 associated with the given pager.

20 In a first aspect of the present invention, the paging
21 system broadcasts identical message data for the selected
22 pager on several stations or frequencies, but offset in
23 time. The predetermined delay between receipt of message
24 data and broadcast of an acknowledge signal is a fixed
25 delay period plus a station dependent delay period. The
26 station dependent delay period staggers acknowledge

1 signals from pagers receiving message data concurrently
2 on different stations and enables the paging system to
3 uniquely associate each acknowledge signal with one
4 pager.

5 In a second aspect of the present invention, the pager
6 broadcasts a low wattage acknowledge signal to conserve
7 power and the paging system includes a network of
8 acknowledge signal receivers distributed through the
9 paging area for reporting times at which acknowledge
10 signals occur within the paging area.

11 Brief Description of the Drawings

12 A complete understanding of the present invention may be
13 obtained by reference to the accompanying drawings, when
14 taken in conjunction with the detailed description
15 thereof and in which:

16 FIG. 1 illustrates a paging system including remote
17 pagers and corresponding pager address values uniquely
18 identifying each pager and determining associated message
19 data time slots;

20 FIG. 2 illustrates a set of time frames each including
21 sub-frames comprising message data time slots, wherein
22 identical message data is transmitted on different
23 broadcast stations each referencing a different time

- 1 frame, and each time frame is offset in time relative to
- 2 the other time frames;
- 3 FIG. 3 illustrates concurrence of time slots between the
- 4 time frames of FIG. 2 and time intervals in which
- 5 acknowledge signals occur;
- 6 FIG. 4 illustrates the paging system of FIG. 1 and an
- 7 acknowledge signal receiver network with the remote
- 8 pagers of FIG. 1 located within the network;
- 9 FIG. 5 is a flow chart for broadcasting an acknowledge
- 10 signal from one of the remote pagers;
- 11 FIG. 6 illustrates a dedicated frequency subband
- 12 containing an acknowledge signal;
- 13 FIG. 7 is a flow chart for processing acknowledge signals
- 14 at the acknowledge signal receivers of FIG. 3;
- 15 FIG. 8 is a block diagram of one of the acknowledge
- 16 signal receivers of FIG. 3; and
- 17 FIG. 9 is a flow chart for processing reports from the
- 18 acknowledge signal receivers.
- 19 Description of the Preferred Embodiment

1 For expository convenience, the present invention will be
2 illustrated with reference to a paging system (the
3 "Gaskill system") described in U.S. Patent 4,713,808 and
4 in allowed application Serial No. 07/121,139. However,
5 it will be understood that the invention is not so
6 limited. The disclosures of U.S. Patent 4,713,808 and
7 allowed application Serial No. 07/121,139 are
8 incorporated herein by reference.

9 The Gaskill system includes a number of wrist-watch
10 remote pagers 10, individually numbered 10a-10d in FIG.
11 1, each having an associated pager address value 12,
12 individually numbered 12a-12d in FIG. 1, for identifying
13 each remote pager 10 and determining when each remote
14 pager 10 activates to receive message data. As fully
15 explained in U.S. Patent No. 4,713,808, and discussed
16 hereafter, address values 12 specify sub-frames of
17 repeating time frames and further specify time slots
18 within the sub-frames in which the corresponding remote
19 pagers 10 activate to receive message data.

20 FIG. 1 also illustrates a central clearinghouse 20 for
21 processing and broadcasting message data to remote pagers
22 10. Clearinghouse 20 communicates by way of
23 communication link 22 to antenna tower 24 for
24 broadcasting an FM radio signal to remote pagers 10.
25 Clearinghouse 20 is a fully automated, centralized
26 facility which accepts messages, validates customer

1 identification, determines message destinations, and
2 routes messages to the appropriate broadcast stations
3 facility, e.g., tower 24, for transmission.

4 In accordance with the protocol of the Gaskill system,
5 each remote pager 10 is programmed to activate during
6 predetermined time slots and monitor one of several
7 broadcast stations or frequencies for message data. In
8 accordance with the present invention, each of remote
9 pagers 10 then provides an acknowledge signal 14 to
10 clearinghouse 20 following a predetermined delay relative
11 to message receipt, more particularly, relative to the
12 predetermined time slot. A particular acknowledge signal
13 14 is then associated with one of remote pagers 10 based
14 on the time at which the acknowledge signal 14 is
15 broadcast. Such association is accomplished by
16 offsetting the time at which the acknowledge signal 14 is
17 broadcast by the predetermined delay to derive a time
18 slot uniquely associated with one of remote pagers 10.

19 FIG. 2 illustrates the message protocol of the Gaskill
20 system. A time frame 30 of predetermined length, such as
21 7 and one-half minutes, repeats cyclically. Within time
22 frame 30 are a predetermined number of sub-frames,
23 represented as rows in FIG. 2. As shown, time frame 30
24 is divided into 32 such sub-frames, numbered 0 to 31, of
25 about 14 seconds each. Each of sub-frames 0-31 is, in
26 turn, divided into a predetermined number of time slots

1 40. The first three time slots 40 of each sub-frame are
2 reserved for control data and the remaining time slots 40
3 in each sub-frame are reserved for message data. Each
4 time slot 40 is then approximately fourteen milliseconds
5 in duration. Each message data time slot 40 of each sub-
6 frame is uniquely numbered, i.e., 0 to 1,023.

7 Address values 12 for each remote pager 10 determine
8 which time slots 40 in time frame 30 are associated with
9 a given remote pager 10. For example, remote pager 10a
10 of FIG. 1 is programmed to activate 8 times during each
11 time frame 30, beginning in message data time slot number
12 38 of sub-frame 2 and repeating every fourth sub-frame,
13 i.e., in subsequent sub-frames 6, 10, 14, 18, 22, 26 and
14 30. In FIG. 2, remote pager 10a activates during time
15 slots 40a. Similarly, remote pager 10b activates during
16 time slots 40b, remote pager 10c activates during time
17 slots 40c and remote pager 10d activates during time
18 slots 40d. In each case, only the first three time slots
19 40 associated with each remote pager 10 are shown in FIG.
20 2.

21 The Gaskill system also employs multiple stations for
22 broadcasting identical message data. Each station
23 broadcasts the same message data, but offset in time such
24 that an individual remote pager 10 may switch stations
25 and receive a message at a later time in the event that

- 1 message data is lost, errors are detected or
- 2 re-synchronization is necessary.

3 Thus, identical message data is broadcast during time
4 frame 32 as is broadcast during time frame 30, but offset
5 in time relative to time frame 30 by a fixed amount. The
6 time offset P_0 between time frame 30 and time frame 32 is
7 equal to one sub-frame plus sixteen time slots 40.
8 Similarly, identical message data is broadcast during
9 time frame 34, but offset relative to time frame 32 by
10 the time offset P_0 . Accordingly, if time frame 30 begins
11 at a time T_0 , time frame 32 begins at a time $T_0 + P_0$ and
12 time frame 34 begins at a time $T_0 + (2 \cdot P_0)$.

13 In the following discussion, it will be assumed that
14 message data is broadcast on three separate active
15 broadcast stations each referencing one of time frames
16 30, 32, and 34. However, it will be understood that
17 additional broadcast stations referencing additional time
18 frames 36 may be potentially active. Accordingly, it
19 will be further assumed that the system is capable of
20 broadcasting on up to seven different active stations,
21 each referencing a separate one of time frames 30, 32, 34
22 and 36. Because the time offset P_0 is a multiple of time
23 slots, a concurrence of time slots on different stations
24 exists. For three active broadcast stations, three time
25 slots 40 coincide, each coincident time slot 40 being
26 associated with a respective one of the time frames 30,

1 32 and 34. For each additional active broadcast station,
2 additional time slots 40 coincide.

3 FIG. 3 better illustrates the concurrence of time slots
4 among time frames 30, 32, 34 and 36. In FIG. 3, each
5 time frame may be viewed as a repeating sequence of time
6 slots 40. Time frames 30, 32, 34 and 36 are shown as
7 individual rows of time slots 40. Time line 50 begins at
8 time T₀ and is divided into major time intervals 52, each
9 major time interval 52 being equal in duration to one
10 time slot 40 and corresponding to a set of concurrent
11 time slots 40. Each major interval 52 is divided into
12 seven minor intervals 54, each minor interval 54
13 corresponding to one of the seven possible broadcast
14 stations. Time slots 40 aligned in columns, as shown in
15 FIG. 3, are coincident time slots. For example, the
16 column 56 contains seven time slots 40, each members of
17 respective ones of times frames 30, 32, 34 and 36 and
18 concurrent in time during a major time interval 58.

19 To implement the present invention in a paging system
20 employing a single broadcast station referencing a single
21 time frame, the delay period between message receipt and
22 broadcast of an acknowledge signal from the receiving
23 remote pager 10 is a fixed delay FD, a multiple of time
24 slots totalling approximately one second in duration.
25 Fixed delay FD should be long enough for worst case
26 message data processing by a remote pager 10. Consider

1 remote pager 10a referencing time frame 30, and receiving
2 message data during time slot 40a occurring during major
3 time interval 58. To verify message receipt, remote
4 pager 10a broadcasts its acknowledge signal 14a during
5 major time interval 60, offset from major interval 58 by
6 the fixed delay FD. In a paging system employing a
7 single broadcast station referencing time frame 30, each
8 major interval 52 of time line 50 may be associated with
9 a single time slot 40 of time frame 30. Clearinghouse 20
10 associates an acknowledge signal received during major
11 time interval 60 with remote pager 10a by subtracting
12 fixed delay FD from major interval 60 to derive major
13 interval 58 which correlates uniquely with pager 10a, and
14 more particularly, with a message sent to pager 10a.

15 To implement the present invention in a paging system
16 employing multiple broadcast stations each referencing
17 separate time frames, the delay period between message
18 receipt and broadcast of an acknowledge signal by a
19 remote pager 10 must depend on two factors. First, the
20 predetermined fixed delay FD allowing for worst case
21 message processing at the remote pager 10. Second, a
22 station dependent delay SD providing an offset within
23 each major interval 52 to derive a minor interval 54
24 corresponding to a given station. Each major interval 52
25 is associated with a column of concurrent time slots 40
26 by offsetting the fixed delay FD. Each minor interval 54
27 is associated with one of the concurrent time slots by

1 determining the station dependent delay SD, i.e., the
2 offset within the major time interval 54. In this
3 manner, every minor time interval 54 of time line 50 is
4 uniquely associated with one time slot 40 in one of time
5 frames 30, 32, 34, or 36.

6 To illustrate concurrence of time slots 40 among
7 different time frames, the specific address values 12a
8 12c, 12d, etc. of pagers 10a, 10c, and 10d has been chosen
9 to cause time slots 40a, 40c, and 40d to coincide, i.e.,
10 to cause pagers 10a, 10c, and 10d to activate and monitor
11 different stations or frequencies during the same major
12 time interval 58. It should be understood, however, that
13 remote pagers 10 are given address values 12 such that
14 they tend to activate during non-concurrent time slots
15 40.

16 Recall that the frame offset F0 is equal to one sub-
17 frame plus sixteen time slots 40. Note, as seen in FIG.
18 2, that the first time slot 40a in time frame 30 occurs
19 in sub-frame 2, slot number 38; the first time slot 40c
20 in time frame 30 occurs in sub-frame 1, slot number 22;
21 and the first time slot 40d in time frame 30 occurs in
22 sub-frame 0, slot number 6. The offset between time
23 slots 40a, 40c, and 40d was chosen, for purposes of
24 illustration, to be equal to one sub-frame plus sixteen
25 time slots 40, equal to the frame offset F0. Because
26 time frame 34 is offset or delayed relative to time frame

1 32 by frame offset F0, the first time slot 40d in time
2 frame 34 is coincident with the first time slot 40c in
3 time frame 32. Similarly, the first time slot 40c of
4 time frame 32 is coincident with the first time slot 40a
5 of time frame 30. Subsequent time slots 40a, 40c, and
6 40d in each of time frames 30, 32 and 34, i.e., the
7 second through eighth, would also coincide as each bears
8 the same relative offset as does the first. Thus, as
9 shown in FIG. 3, time slots 40a, 40c, and 40d appear in
10 the column 56 above major time interval 58 as concurrent
11 time slots.

12 Consider a situation where remote pager 10d is tuned to a
13 first station referencing time frame 34, remote pager 10c
14 is tuned to a second station referencing time frame 32,
15 and remote pager 10a is tuned to a third station
16 referencing time frame 30. Furthermore, assume that
17 clearinghouse 20 has message data for each of remote
18 pagers 10a, 10c, and 10d, and, in accordance with normal
19 operating procedures, causes transmission on separate
20 stations of such message data during major time interval
21 58. Each of remote pagers 10a, 10c, and 10d receives, on
22 separate broadcast stations, message data during major
23 time interval 58. Assuming remote pagers 10a, 10c, and
24 10d process the message data and determine the data to be
25 error-free, each must broadcast an acknowledge signal 14
26 to clearinghouse 20 to acknowledge receipt. In
27 accordance with the above example, each remote pager 10a,

1 10c, and 10d broadcasts its acknowledge signal 14 during
2 major time interval 60, offset relative to major time
3 interval 58 by fixed delay FD. However, each remote
4 pager 10a, 10c, and 10d broadcasts its acknowledge signal
5 14 during different minor time intervals 54 of major time
6 interval 60. For example, remote pager 10d, being tuned
7 to the first station, broadcasts its acknowledge signal
8 14d during the first minor time interval 64; remote
9 pager 10c, being tuned to the second station, broadcasts
10 its acknowledge signal 14c during the second minor time
11 interval 66; and remote pager 10a, being tuned to the
12 third station, broadcasts its acknowledge signal 14a
13 during the third minor time interval 68. Accordingly,
14 the station dependent delay SD0 for a remote pager 10,
15 e.g., 10d, tuned to the first station is zero; the delay
16 SD1 for remote pager 10, e.g., 10c, tuned to the second
17 station is equal to one minor time interval 54; and the
18 delay SD2 for a remote pager 10, e.g., 10d, tuned to the
19 third station, is equal to two minor time intervals 54.

20 In a situation where clearinghouse 20 broadcasts message
21 data on seven different stations, seven remote pagers 10
22 each can be tuned to a different station and each may
23 receive message data during the same major time interval
24 52. In such case, each remote pager 10 broadcasts its
25 acknowledge signal during a different minor time interval
26 54 of one major time interval 52. Clearinghouse 20
27 distinguishes among the seven acknowledge signals by

1 determining the minor time interval 54 in which each
2 occurs. Generally, if a paging system uses n stations to
3 broadcast message data, and up to n remote pagers 10
4 potentially receive message data during a single major
5 time interval 52, each major time interval 52 must be
6 divided into n minor time intervals 54 to distinguish
7 among the possible n acknowledge signals during each
8 major time interval 52.

9 A central concern in the Gaskill paging system is
10 conservation of power consumption at remote pagers 10.
11 In accordance with this concern, the acknowledge signal
12 broadcast from a remote pager 10 should be a low wattage
13 signal, however, such an acknowledge signal is not
14 essential to practice of the present invention in its
15 broader aspects. Furthermore, because an acknowledge
16 signal 14 is associated with a remote pager 10 based upon
17 the time at which the acknowledge signal is broadcast by
18 the remote pager 10, the acknowledge signal 14 need only
19 carry a single bit or binary value. Broadcast of a
20 single bit acknowledge signal is more power efficient
21 than broadcast of an acknowledge signal carrying more
22 information, such as conventional acknowledge signals
23 carrying information identifying the remote pager, i.e.,
24 the signal source, to the paging system.

25 FIG. 4 illustrates a network of acknowledge signal
26 receivers 70 distributed within a paging area occupied by

1 remote pagers 10. Acknowledge signal receivers 70 should
2 be spaced closely enough to insure that an acknowledge
3 signal 14 of a given wattage broadcast by one of the
4 remote pagers 10 has a good chance of being received by
5 at least one of the acknowledge signal receivers 70. Of
6 course, local terrain and noise conditions must be
7 considered. However, for a higher wattage acknowledge
8 signal 14 the acknowledge signal receivers 70 may be more
9 widely spaced, and for a lower wattage acknowledge signal
10 the acknowledge signal receivers 70 must be more closely
11 spaced.

12 Each of acknowledge signal receivers 70 communicates with
13 clearinghouse 20 by way of communication link 72 which,
14 for example, may be a telephone connection or a microwave
15 connection. Each of acknowledge signal receivers 70 is
16 responsible for determining the probability of occurrence
17 of an acknowledge signal during each minor time
18 interval 54 of time line 50. Each acknowledge signal
19 receiver 70 then reports such probability of occurrence
20 for each minor time interval 54 by way of link 72 to
21 clearinghouse 20. Clearinghouse 20 processes the
22 reported probabilities of acknowledge signal occurrence
23 from all acknowledge signal receivers 70 and determines
24 whether an acknowledge signal 14 has occurred during a
25 particular minor time interval 54. Upon determining that
26 an acknowledge signal 14 has occurred during a particular
27 minor time interval 54, clearinghouse 20 is then able to

1 associate the particular minor time interval 54 with a
2 particular time slot 40 and therefore with a particular
3 message transmitted to a particular remote pager 10. The
4 desired message receipt verification is thereby achieved.

5 FIG. 5 illustrates the process of receiving message
6 data at one of remote pagers 10 and broadcasting an
7 acknowledge signal 14 to verify receipt of the message
8 data. Process blocks 80, 82 and 83 represent the normal
9 operating procedures of the Gaskill paging system. In
10 process block 80, remote pager 10 activates during a
11 predetermined time slot occurring during major time
12 interval Tx. Remote pager 10 monitors a broadcast
13 station Z for message data occurring during that time
14 slot. Processing then continues into decision block 82.
15 In decision block 82, remote pager 10 determines whether
16 or not valid message data containing its address value 12
17 has been received. If such message data has not been
18 received, processing returns to block 80 where remote
19 pager 10 reactivates during a subsequent time slot and
20 attempts to again intercept message data during its
21 assigned time slot.

22 If a remote pager 10 receives valid message data
23 containing its address value 12 during a major time
24 interval Tx, processing branches from decision block 82
25 into blocks 83 and 84. In process block 83, the message
26 is displayed for the user and processing continues in

1 block 84. In process block 84, remote pager 10
2 broadcasts and acknowledges signal 14 during a later
3 minor time interval as determined by the interval Tx in
4 which the message data was received, the fixed delay FD,
5 and the station dependent delay SDz. To calculate the
6 total delay period, remote pager 10 first adds the fixed
7 delay FD to major time interval Tx. The station
8 dependent delay SD is a function of the broadcast station
9 from which the message was received. For example, if the
10 message was received on the first station, delay SDz is
11 zero; if the message was received on the second station,
12 delay SDz is equal to one minor time interval 54; if the
13 message was received on the third station, delay SDz is
14 equal to two minor time intervals 54. After broadcasting
15 the acknowledge signal, processing then returns to
16 block 80.

17 FIG. 6 illustrates the spectrum of subband fb in which an
18 acknowledge signal 14 occurs. Due to temperature
19 variations and imperfections in the crystal used as a
20 frequency reference to generate the acknowledge signal
21 14, the acknowledge signal 14 may occur at any frequency
22 within frequency subband fb. The maximum duration for
23 acknowledge signal 14 is equal to one minor time interval
24 54. That is to say, the maximum duration is dependent on
25 the duration of major time intervals 52 and the number of
26 potential stations upon which the paging system can
27 broadcast. For a system employing a major time interval

1 of approximately fourteen milliseconds, and 7 possible
2 broadcast stations or frequencies, the maximum duration
3 for the acknowledge signal 14 is approximately
4 two milliseconds.

5 The task of determining the probability of occurrence of
6 an acknowledge signal 14 during one of minor time
7 intervals 54 requires that acknowledge signal receiver 70
8 detect a low wattage signal of small band width at an
9 unknown location within a much larger band width.

10 FIG. 7 illustrates the procedure for determining the
11 probability of occurrence or of acknowledge signals 14
12 during each of minor time intervals 54. In FIG. 7, each
13 of acknowledge signal receivers 70 performs the following
14 steps. Upon synchronization or resynchronization with
15 clearinghouse 20, acknowledge signal receiver 70 sets, in
16 blocks 90 and 92, a variable Z and a variable Y to index
17 intervals of time line 50. Variables Z and Y provide
18 both clearinghouse 20 and acknowledge signal receiver 70
19 with a common mechanism for identifying minor time
20 intervals 54 of time line 50. The variable Z refers to
21 major time intervals 52 and the variable Y refers to
22 minor time intervals 54 with each major time interval 52.

23 In process block 94, acknowledge signal receiver 70
24 monitors frequency subband fb for an acknowledge signal

1 14 during minor time interval T_y of major time
2 interval T_z . In block 96, receiver 70 calculates as
3 described below, a probability of acknowledge signal
4 occurrence for that minor time interval. In block 98
5 acknowledge signal receiver 70 reports to clearinghouse
6 20 the probability of occurrence of an acknowledge signal
7 14 during this minor time interval.

8 Processing then continues with block 100 where
9 acknowledge signal receiver 70 increments the variable Y
10 to index the next minor time interval on time line 50.
11 In decision block 102, acknowledge signal receiver 70
12 determines whether the variable Y has reached the value
13 $n+1$, where n is the number of possible broadcast stations
14 employed by the paging system. If the variable Y has
15 reached the value $n+1$, the last minor time interval 54 of
16 a major time interval 52 has been reached. It is then
17 necessary to index the variable Z to reference the next
18 major time interval 52. Therefore, in process block 104,
19 the variable Y is reset to reference the first minor time
20 interval 54 of the next major time interval 52. If, in
21 decision block 102, the variable Y had not yet reached
22 the value $n+1$, processing skips block 104. In any case,
23 processing returns to block 94 where acknowledge signal
24 receiver 70 again monitors frequency subband f_b for an
25 acknowledge signal 14 during the next minor time interval
26 54. Thus, each acknowledge signal receiver 70 simply
27 increments variables Z and Y in a suitable manner to

- 1 reference each minor time interval 54 of time line 50 and
- 2 calculate a probability of acknowledge signal occurrence.

3 FIG. 8 is a block diagram of an acknowledge signal
4 receiver 70. In FIG. 8, a remote pager 10 is shown
5 broadcasting an acknowledge signal 14. Acknowledge
6 signal receiver 70 includes an antenna 112 for receiving
7 an acknowledge signal 14. A radio frequency receiver
8 with a band pass filter 114 filters signals outside
9 frequency band fb and feeds its output signal into a fast
10 fourier transform processor 116. Processor 116
11 decomposes its input signal from filter 114 into
12 approximately two hundred frequency bins 118 (FIG. 6).
13 The number of frequency bins 118 is chosen to provide a
14 frequency range for each bin 118 of approximately
15 one-fifth of the main lobe band width expected for
16 acknowledge signal 14. Processor 116 analyzes the energy
17 level of each frequency bin 118 and provides a separate
18 output signal for each bin 118, each output signal
19 representing the energy level of the associated bin 118.

20 In the example shown in FIG. 6, the main lobe of the
21 acknowledge signal spans six frequency bins, bins 120,
22 121, 122, 123, 124 and 125. Processor 116 determines
23 that frequency bins 120 and 125 carry low range energy,
24 bins 121 and 124 carry mid-range energy, and bins 122 and
25 123 carry high-range energy. The remaining frequency

1 bins 118 carry energy levels range correlating to
2 adjacent signal lobes and expected noise levels.

3 The two hundred output signals of processor 116 are fed
4 into a spectral shape recognizer logic block 130 (FIG.
5 8). Logic block 130 determines, based upon the reported
6 energy levels from processor 116, the probability that an
7 acknowledge signal 14 has occurred. Thus, logic 130
8 performs the step represented by block 96 of FIG. 7.
9 More particularly, logic 130 determines with high
10 probability that an acknowledge signal 14 has occurred
11 within frequency subband fb by detecting the presence of
12 a sequence of energy bins having zero or nominal energy
13 levels followed by a sequence of approximately six bins,
14 e.g., bins 120-125, of expected relative energy levels
15 which are in turn followed by a sequence of nominal
16 energy level bins 118. The frequency bin energy levels
17 may not clearly indicate the presence of an acknowledge
18 signal, and logic 130 would calculate a lesser
19 probability of acknowledge signal occurrence. In other
20 cases, the frequency bin energy levels might indicate
21 that no acknowledge signal has occurred and logic 130
22 would calculate a low, or zero, probability of
23 acknowledge signal occurrence. For instance, if logic
24 130 detects high energy levels across all or much more
25 than six frequency bins 118, it may conclude that the
26 signal received was not likely to be an acknowledge
27 signal 14. In any case, acknowledge signal receivers 70

1 calculate a probability of acknowledge signal occurrence
2 based on the expected frequency domain pulse shape as
3 indicated by the energy levels in frequency bins 118.

4 Acknowledge signal receiver 70 performs the above
5 described analysis of frequency subband fb for every
6 minor time interval 54 of time line 50. For each minor
7 time interval 54, logic 130 reports to clearinghouse 20,
8 by way of communication 72, the probability that an
9 acknowledge signal occurred.

10 Fig. 9 illustrates the procedure at clearinghouse 20 for
11 processing reports received from acknowledge signal
12 receivers 70. In this procedure clearinghouse 20 must
13 gather reports sent by acknowledge signal receivers 70
14 for each minor time interval 54 of time line 50.
15 Accordingly, this procedure begins, with respect to a
16 given minor time interval 54, following sufficient time
17 for all acknowledge signal receivers 70 to report an
18 acknowledge signal probability for the given minor time
19 interval 54. Clearinghouse 20 uses variables Z and Y to
20 index time intervals along time line 50.

21 Processing begins in blocks 140 and 142 where the
22 variables Z and Y, respectively, are set to address a
23 given minor time interval 54. Clearinghouse 20 maintains
24 the reports received from acknowledge signal receivers 70
25 in a data structure enabling access based on the

1 variables Z and Y. In block 144 clearinghouse 20
2 analyzes the data structure to determine the reported
3 probabilities of acknowledge signal occurrence during
4 minor time interval T_y of major time interval T_z .

5 Clearinghouse 20 then determines in decision block 146
6 whether the probabilities found in the data structure
7 indicate that a valid acknowledge signal occurred during
8 minor time interval T_y of major time interval T_z , i.e.,
9 the current minor time interval. If all acknowledge
10 signal receivers 70 report a very low or zero acknowledge
11 signal probability during the current minor time
12 interval, then clearinghouse 20 assumes that no valid
13 acknowledge signal occurred during the current minor time
14 interval and processing branches from decision block 146
15 to process block 148. If one acknowledge signal
16 receiver 70 reports with high probability that an
17 acknowledge signal occurred during the current minor time
18 interval then processing branches from decision block 146
19 to process block 150.

20 If, however, several acknowledge signal receivers 70
21 report with mid-level probability that an acknowledge
22 signal occurred during the current minor time interval,
23 the reports could indicate a valid or an invalid
24 acknowledge signal depending on the location of the
25 acknowledge signal receivers 70 reporting the mid-level
26 probability of an acknowledge signal. If two or more
27 widely separated acknowledge signal receivers 70 report a

1 mid-level acknowledge signal probability during the
2 current minor time interval, and the separation is beyond
3 the capability of the low wattage acknowledge signal of
4 the remote pagers 10, then it may be assumed that
5 interference caused the acknowledge signal receivers 70
6 to incorrectly report the possibility that an acknowledge
7 signal occurred. In such case, processing branches from
8 decision block 146 to block 148. On the other hand, if
9 the separation between a group of acknowledge signal
10 receivers 70 reporting a mid-range acknowledge signal
11 probability during the current minor time interval is
12 within the capability of the low wattage acknowledge
13 signal of the remote pagers 10, then the reports are
14 taken to indicate a valid acknowledge signal. In this
15 case processing branches from decision block 146 to block
16 150.

17 If clearinghouse 20 determines that no valid acknowledge
18 signal is indicated for the minor time interval T_y of
19 major time interval T_z , and processing reaches block 148,
20 the variable Y is indexed in block 148 to reference the
21 next minor time interval 54. Then in decision block 152
22 the variable Y is tested against the value $n+1$, where n
23 equals the number of minor time intervals 54 in each
24 major time interval 52. If the variable Y has reached
25 the value $n+1$, then in block 154 the variable Z is
26 indexed to reference the next major time interval and the
27 variable Y is reset to reference the first minor time

1 interval thereof. If the variable Y has not yet reached
2 the value $n+1$, then block 154 is skipped. In any case
3 processing returns to block 144 where probability reports
4 for the next minor time interval 54 are analyzed.

5 If clearinghouse 20 determines that a valid acknowledge
6 signal is indicated, then, in process block 150,
7 clearinghouse 20 associates the current minor time
8 interval with a remote pager 10. Because the fixed delay
9 FD is a multiple of major time intervals 52, that number
10 of major time intervals 52 is subtracted or offset from
11 the variable Z to identify a major time interval 52,
12 hereafter the "target major time interval", in which
13 message data associated with the reported acknowledge
14 signal was broadcast. Those remote pagers receiving
15 message data during the target major time interval 52
16 received message data on different stations. The
17 variable Y differentiates among the remote pagers 10
18 receiving message data concurrently on different stations
19 during the target major time interval. If the variable Y
20 is at its initial value, e.g., one, then it is known that
21 the reported acknowledge signal is associated with a
22 remote pager 10 receiving data by way of the first
23 station and referencing time frame 34. Similarly, if the
24 variable Y is at a next value, then it is known that the
25 acknowledge signal is associated with a remote pager 10
26 tuned to the second station and referencing time frame

1 32. Subsequent values for the variable Y indicate
2 association with other time frames 30 and 36.

3 Once the time frame and target major time interval are
4 determined, it is possible to uniquely associate a remote
5 pager 10 with the reported acknowledge signal. Only one
6 time slot 40 of the identified time frame occurs during
7 the target major time interval. Having determined a
8 particular time slot 40 within a particular time frame,
9 the associated remote pager is determined as being the
10 pager to which the message data of that time slot is
11 directed. Having received an acknowledge signal relative
12 to that remote pager, it is known that the message was
13 properly received.

14 From the foregoing description, it can be seen that the
15 present invention relates to a paging system in which
16 message verification is provided by way of an acknowledge
17 signal broadcast from a remote pager following a
18 predetermined time delay relative to receiving the
19 message. According to the method of the present
20 invention, a single frequency subband may be employed for
21 broadcasting acknowledge signals from remote pagers
22 without competition for the acknowledge signal frequency.
23 A network of acknowledge signal receivers allows for a
24 low wattage acknowledge signal, thereby conserving power
25 consumption at each remote pager.

1 The method of message receipt verification of the present
2 invention is possible in any communication system in
3 which a sending device provides a message to a receiving
4 device at a known time. For example, consider a time
5 multiplexed communication system wherein receiving
6 devices monitor a common message medium, e.g. a common
7 radio frequency, for message data, sending devices
8 provide message data on the communication medium for a
9 particular receiving device by tagging data frames with a
10 suitable identification number, and receiving devices
11 detect the presence of appropriate message data by
12 message frames bearing a matching identification number.
13 The time at which a receiving device receives the message
14 is known by the sending device because the sending device
15 determines when the message is provided. In accordance
16 with the present invention, the receiving device provides
17 an acknowledge signal following a predetermined, or
18 known, delay relative to receipt of the message. The
19 sending device has sufficient information to determine
20 the source of the acknowledge signal based on the time at
21 which it receives the acknowledge signal, and thereby
22 verify message receipt.

23 While the present invention has been shown in the context
24 of the Gaskill paging system, it should be understood
25 that the scope of the present invention should not be so
26 limited. Since other modifications and changes varied to
27 fit particular operating requirements and environments

1 will be apparent to those skilled in the art, the
2 invention is not considered limited to the example chosen
3 for purposes of disclosure, and covers all changes and
4 modifications which do not constitute departures from the
5 true spirit and scope of this invention.

1 WE CLAIM:

- 2 1. In a communication system including a sending
3 device and a receiving device, a method of
4 verifying receipt of a message comprising the
5 steps:
- 6 o providing the message from the sending device
7 to the receiving device at a message time
8 known to said sending device;
 - 9 o providing an acknowledge signal from the
10 receiving device to the sending device
11 following a known delay relative to said
12 message time; and
 - 13 o verifying at the sending device receipt of
14 the message at the receiving device by
15 offsetting the time of receiving the
16 acknowledge signal at the sending device with
17 the known delay to derive the message time
18 and thereby associate the acknowledge signal
19 with the receiving device.
- 20 2. The method according to claim 1 wherein said
21 communication system is a paging system, said
22 sending device is a message broadcast facility,
23 said receiving device is a remote pager, and said

1 receiving and sending devices communicate by
2 radio signal means.

3 3. The method according to claim 1 wherein said
4 sending device provides messages to a plurality
5 of receiving devices on separate communication
6 mediums, each of said receiving devices provides
7 an acknowledge signal relative to a message
8 received from the sending device following a
9 delay dependent on a fixed delay period plus a
10 communication medium dependent delay period.

11 4. The method according to claim 4 wherein the
12 separate communication mediums are radio signal
13 stations and the communication dependent delay
14 period is a function of the station from which
15 the message to be acknowledged was received.

16 5. The method according to claim 1 wherein said
17 message time is a predetermined message time for
18 said receiving device.

19 6. In a pager system having a clearinghouse for
20 broadcasting message data and a plurality of
21 remote pagers each programmed to receive message
22 data from the clearinghouse during an associated
23 time slot, a method of acknowledging receipt of

1 message data by one of said remote pagers
2 comprising the steps:

- 3 o receiving message data at said one remote
4 pager during a time slot associated with said
5 one remote pager;
- 6 o broadcasting an acknowledge signal from said
7 one remote pager at a given time, said given
8 time being offset from said time slot by a
9 predetermined delay time;
- 10 o receiving said acknowledge signal at said
11 given time; and
- 12 o offsetting said predetermined delay time from
13 said given time to derive said time slot
14 associated with said one remote pager and
15 thereby associate said acknowledge signal
16 with said one remote pager.

17 7. The method according to claim 6 wherein said step
18 of receiving said acknowledge signal comprises
19 the steps:

- 20 o providing a network of acknowledge signal
21 receivers distributed through an area in
22 which said one remote pager may be located,
23 each of said acknowledge signal receivers
24 being in communication with said
25 clearinghouse;

- o determining the probability of acknowledge signal occurrence at each of said acknowledge signal receivers during predetermined time intervals, each of said predetermined time intervals being time intervals in which said given time may potentially occur; and
- o reporting from each of said acknowledge signal receivers to said clearinghouse the probability of acknowledge signal occurrence during each of said predetermined time intervals,

whereby said clearinghouse performs the step of offsetting said predetermined delay time from one of said predetermined time intervals in which one or more acknowledge signal receivers indicate the probability of acknowledge signal occurrence.

8. The method according to claim 6 wherein said clearing house broadcasts message data on a plurality of stations, said remote pagers selectively tune to said stations to receive message data, and said predetermined delay between receipt of message data and broadcast of an acknowledge signal relative thereto is a function of the station from which the message data is received.

- 1 9. A pager system comprising:
- 2 o a plurality of remote pagers each programmed
- 3 to receive message data during time slots
- 4 associated therewith and to broadcast an
- 5 acknowledge signal at a time following a
- 6 predetermined delay relative to receipt of
- 7 message data; and
- 8 o a clearinghouse for broadcasting message data
- 9 to selected ones of said plurality of remote
- 10 pagers, said message data for a selected
- 11 remote pager being broadcast during a time
- 12 slot associated with said selected remote
- 13 pager, said clearinghouse receiving
- 14 acknowledge signals from ones of said
- 15 plurality of remote pagers and associating a
- 16 given acknowledge signal with a given remote
- 17 pager by offsetting the time of receiving the
- 18 given acknowledge signal by said
- 19 predetermined delay interval to identify a
- 20 time slot associated with the given remote
- 21 pager and thereby identify the given remote
- 22 pager broadcasting the given acknowledge
- 23 signal.
- 24 10. The paging system according to claim 9 wherein
- 25 said clearing house broadcasts message data on a
- 26 plurality of stations, said remote pagers

1 selectively tune to said stations to receive
2 message data, and said predetermined delay
3 interval is a function of the station from which
4 the message is received.

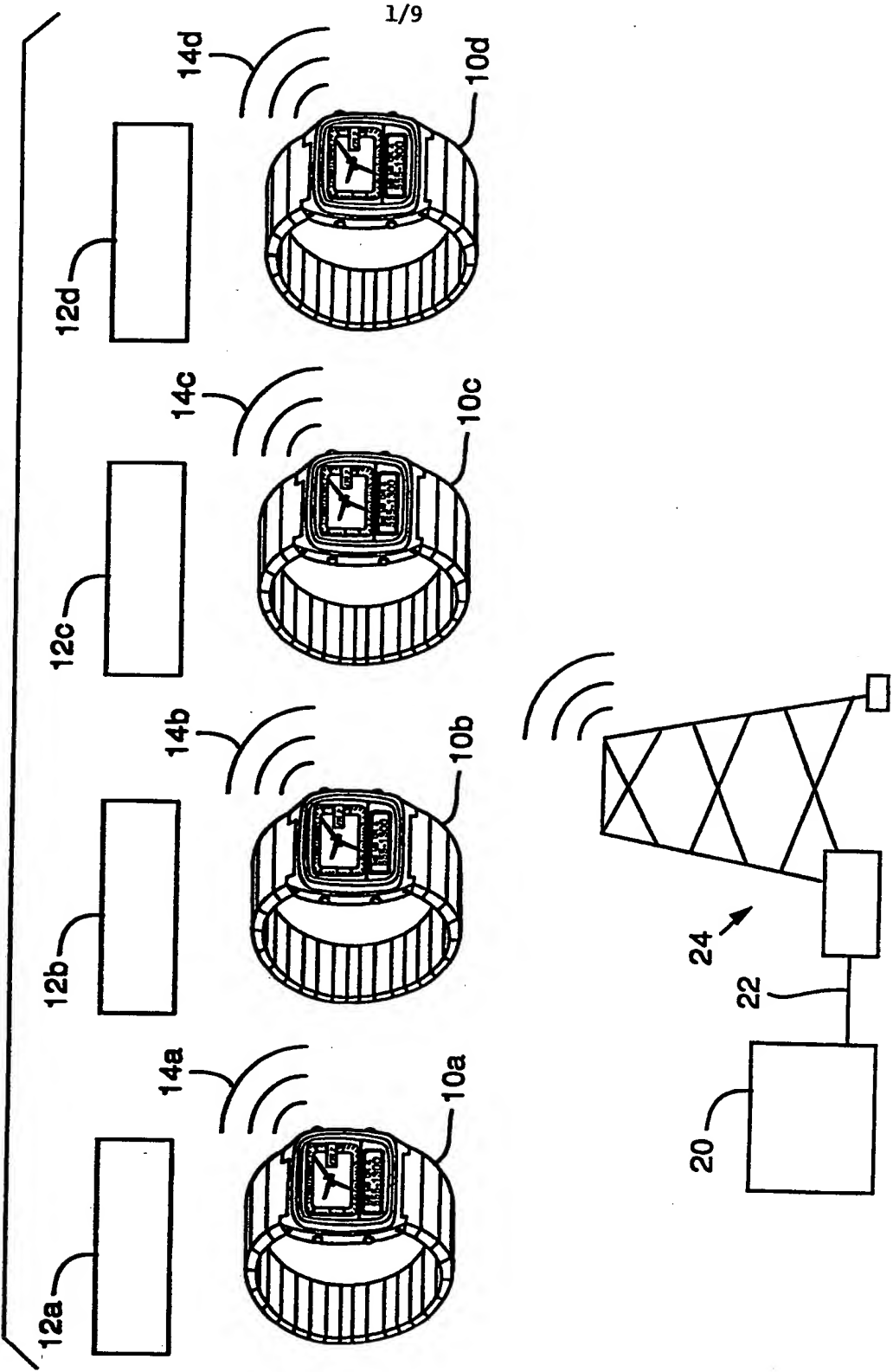
5 11. A paging system comprising:

- 6 o a clearinghouse for broadcasting message data
7 during time slots, said message data being
8 provided on a plurality of stations each
9 referencing a cyclic time frame comprising a
10 sequence of said time slots, the time frames
11 being offset in time by a multiple of time
12 slots whereby time slots of different time
13 frames coincide;
- 14 o a plurality of remote pagers each being
15 associated with time slots of each time frame
16 and programmed to select from said stations
17 for receiving message data during associated
18 time slots, said remote pagers being
19 programmed to provide an acknowledge signal
20 to said clearinghouse relative to receipt of
21 a message following an acknowledge delay
22 period dependant on the station from which
23 said message data was received.

24 12. The paging system according to claim 11 wherein
25 said acknowledge delay period is a fixed delay
26 period plus a station dependent delay period.

1 13. The paging system according to claim 11 wherein
2 said clearinghouse comprises a network of
3 acknowledge signal receivers distributed through
4 an area in which said remote pagers are located
5 and said acknowledge signal receivers calculate a
6 probability of acknowledge signal occurrence for
7 each time interval in which an acknowledge signal
8 potentially occurs.

FIG. 1



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FIG. 2
(Prior Art)

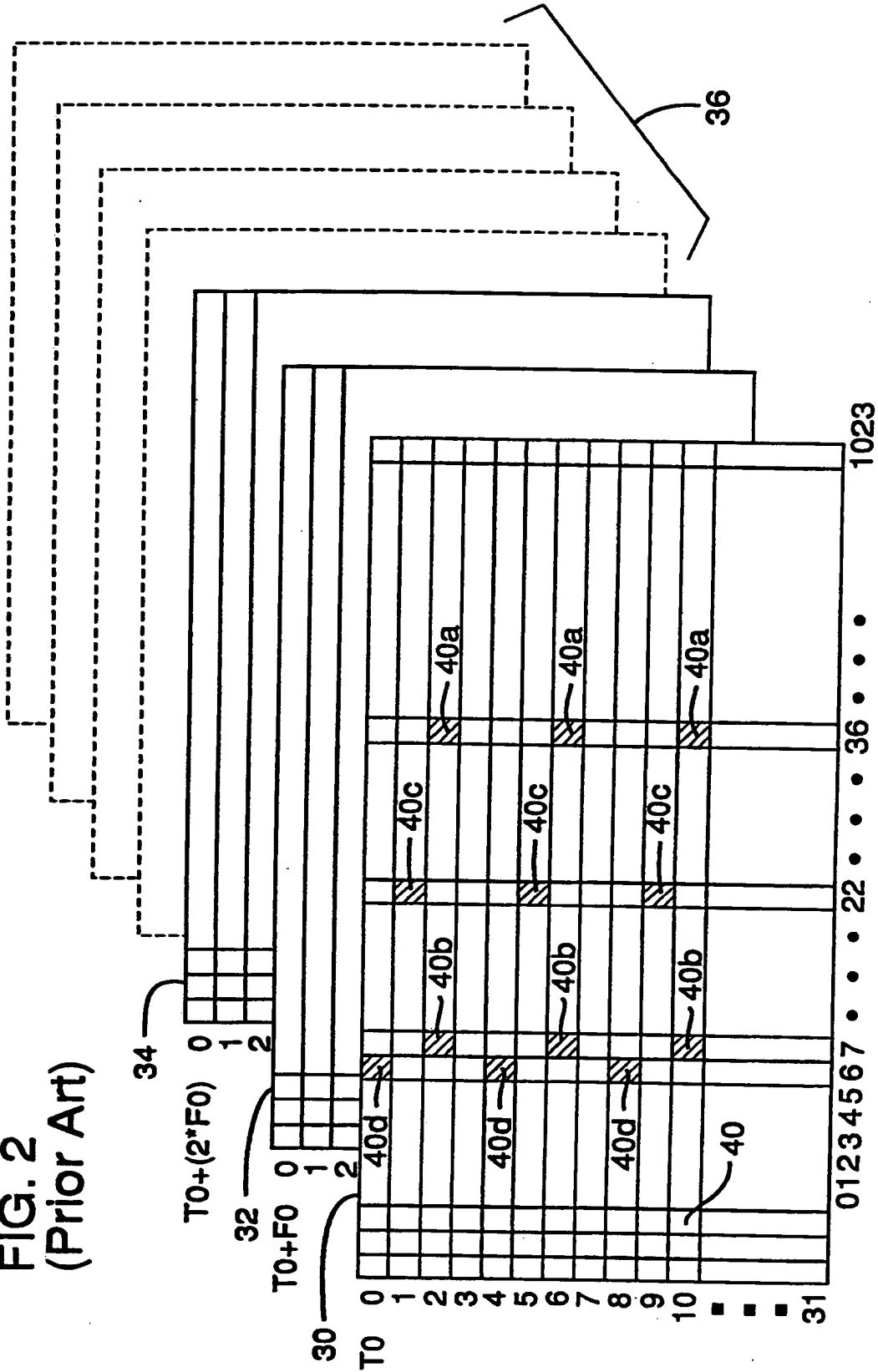
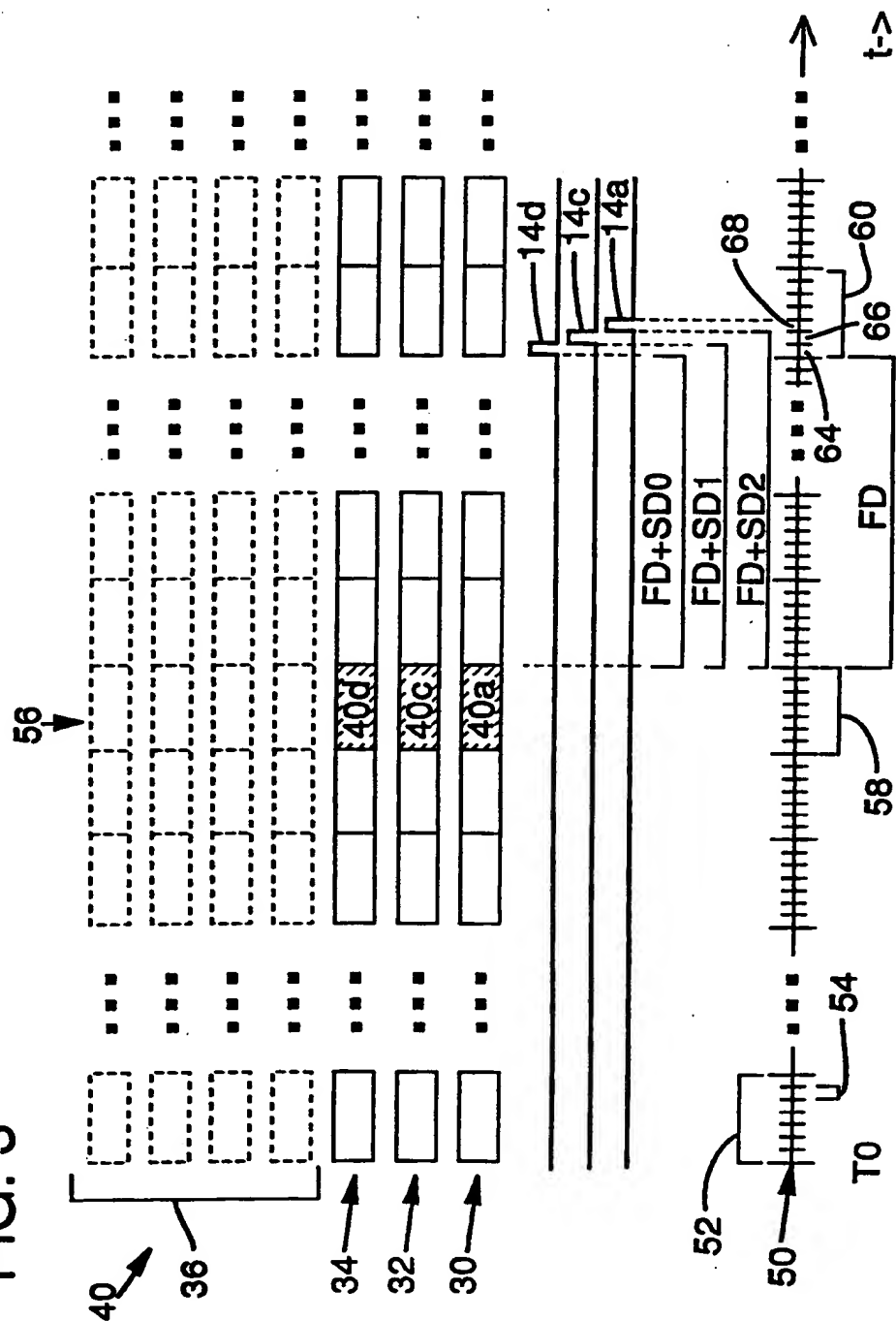


FIG. 3



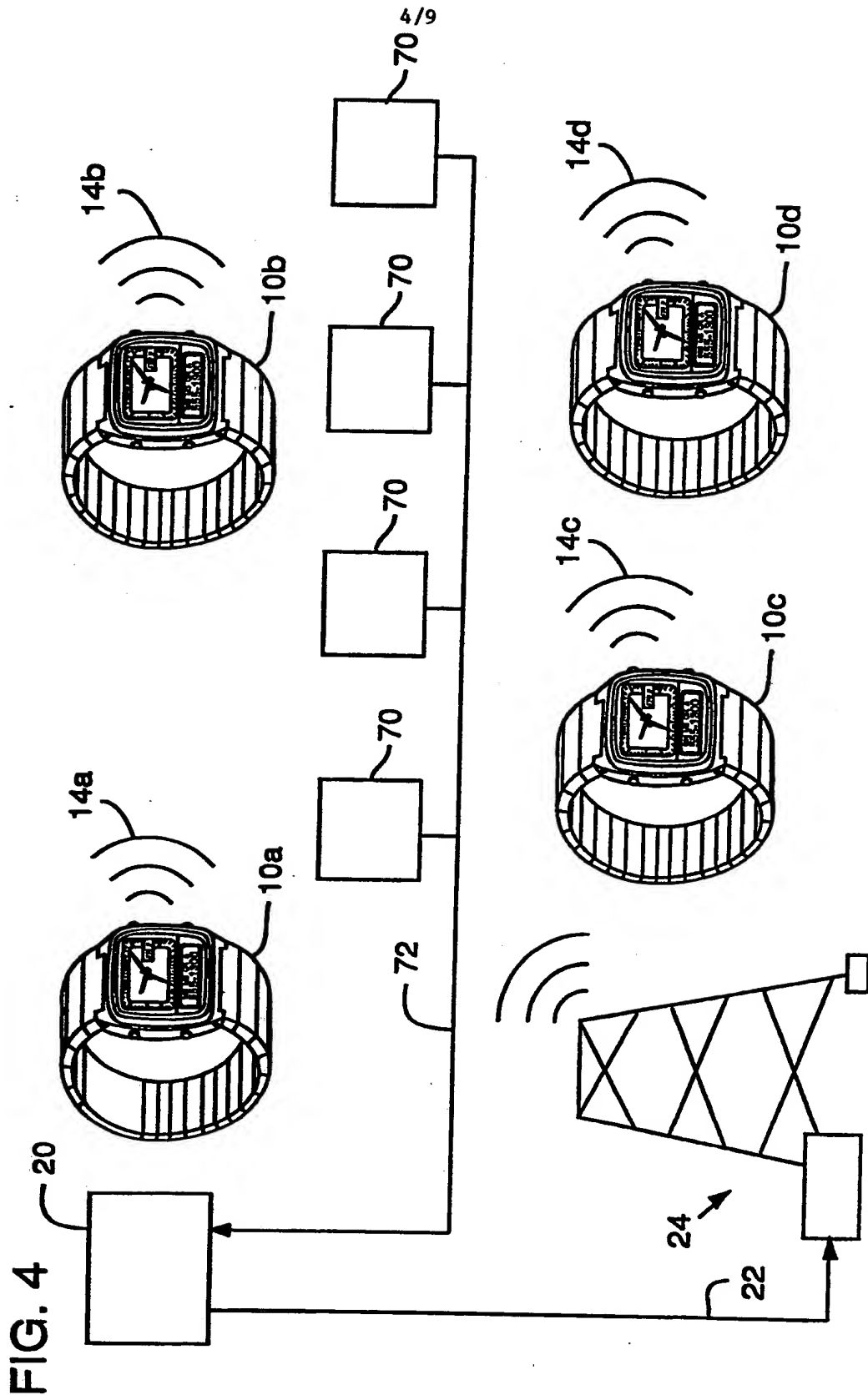
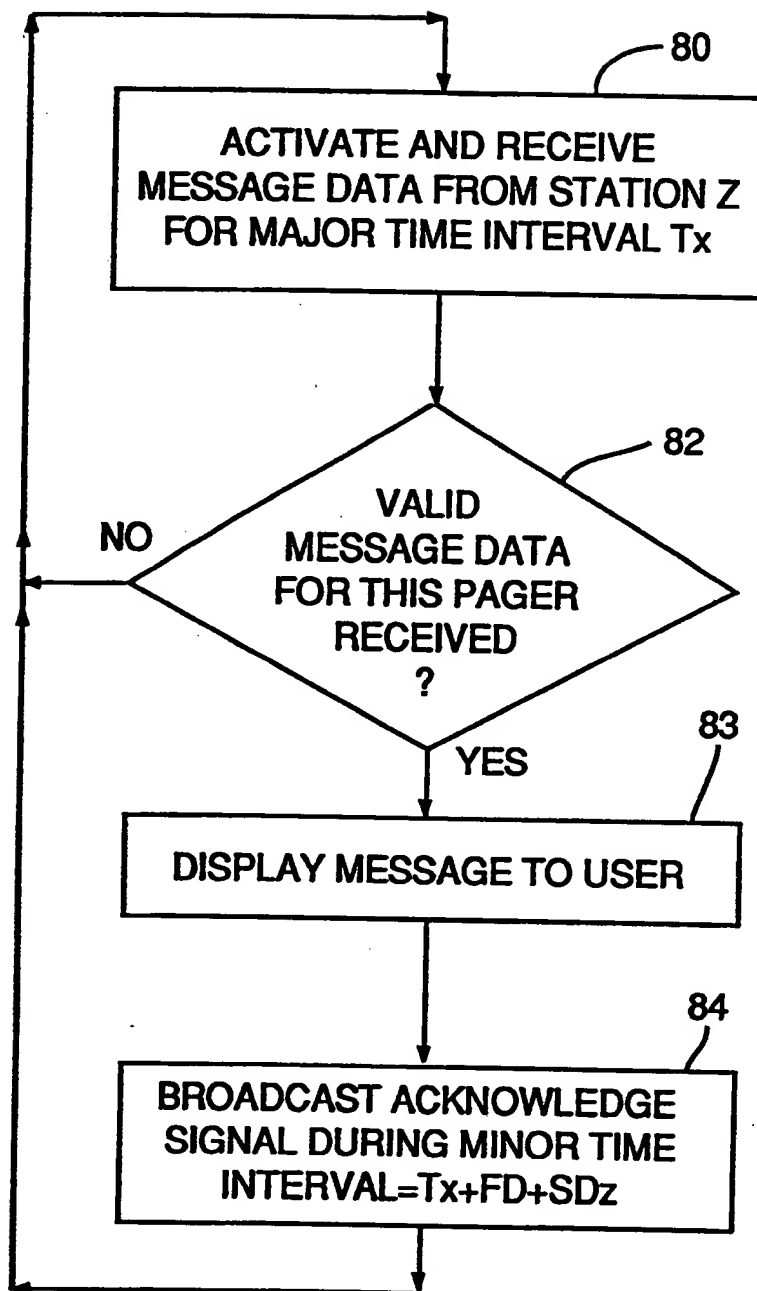
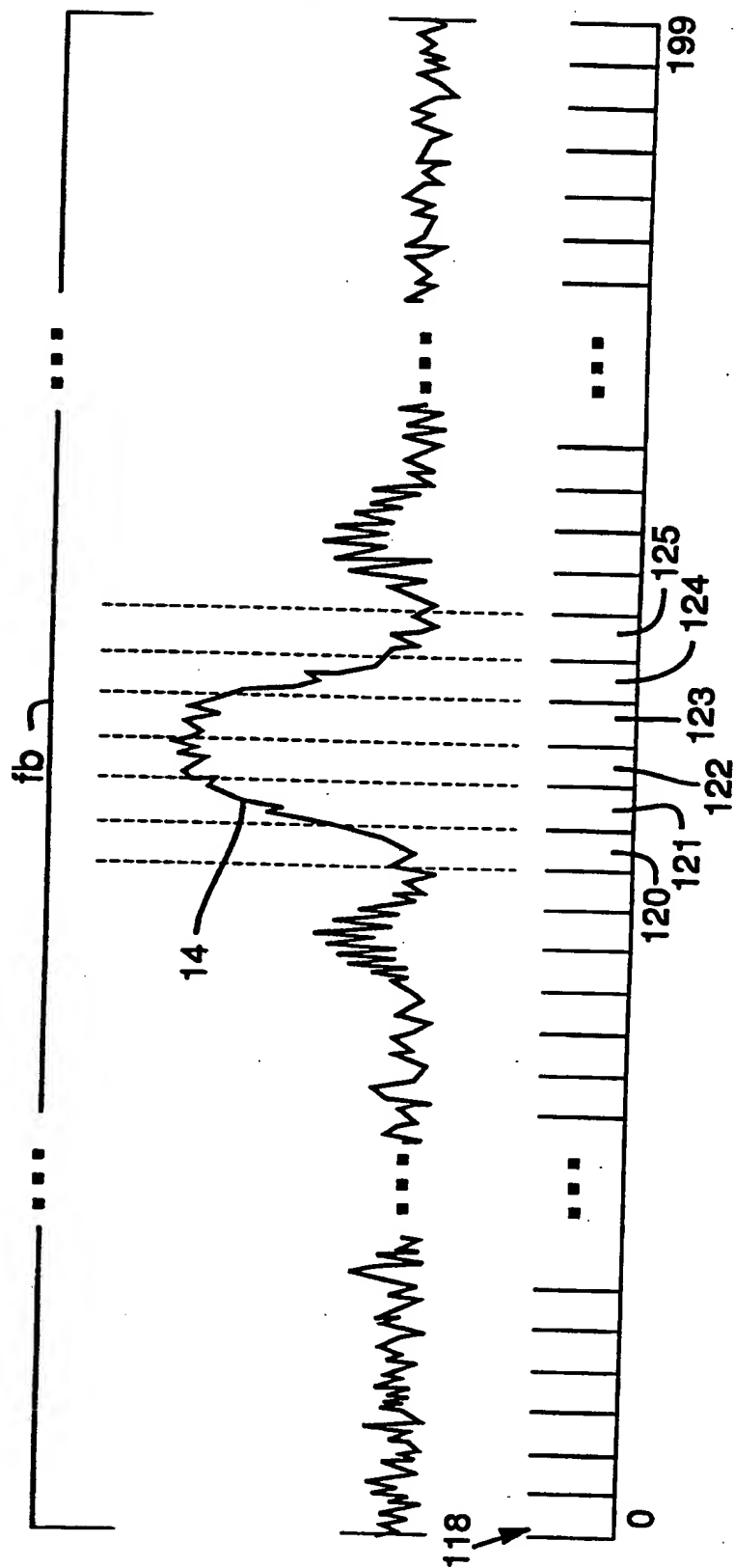


FIG. 5



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FIG. 6



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FIG. 7

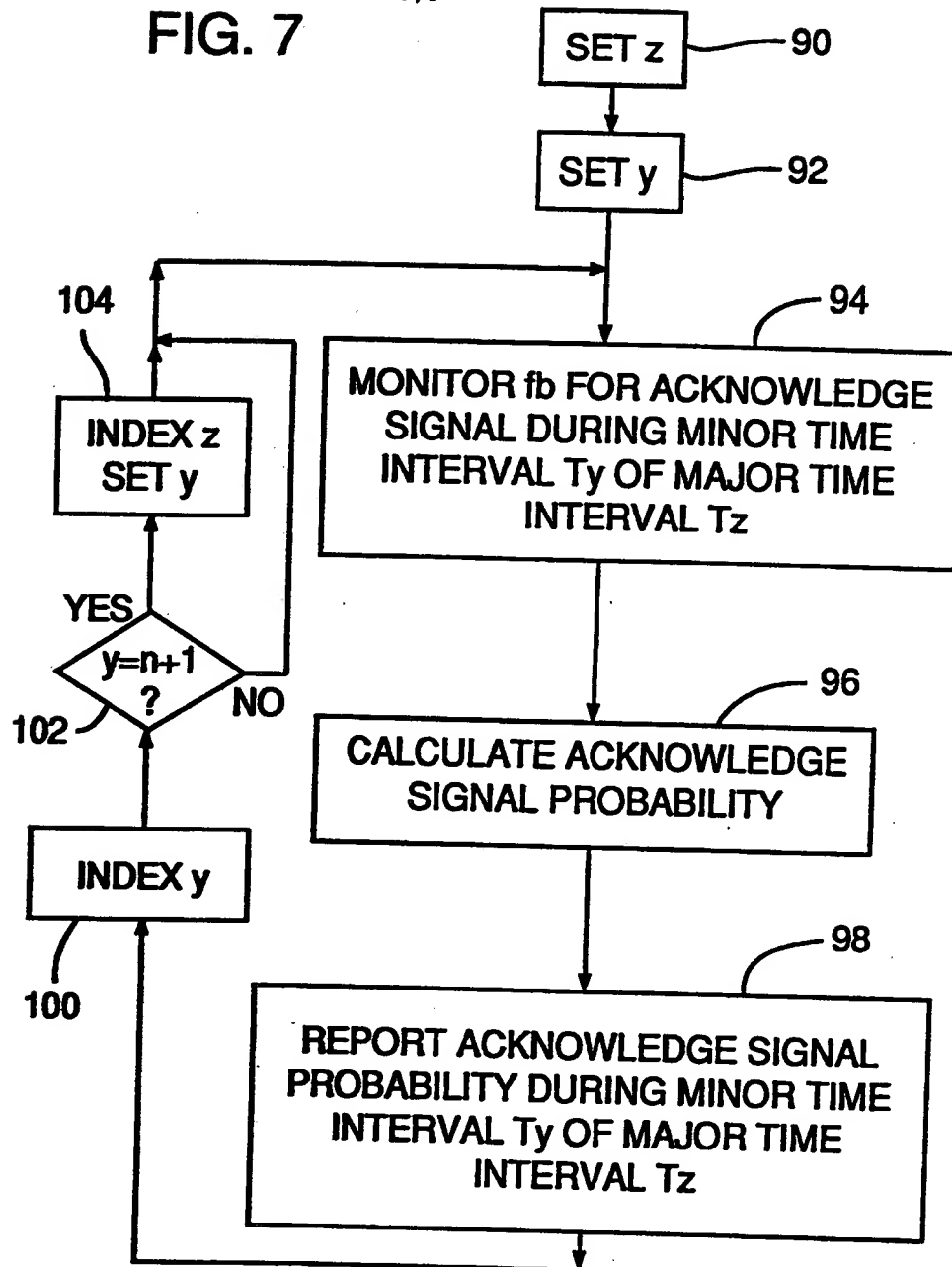
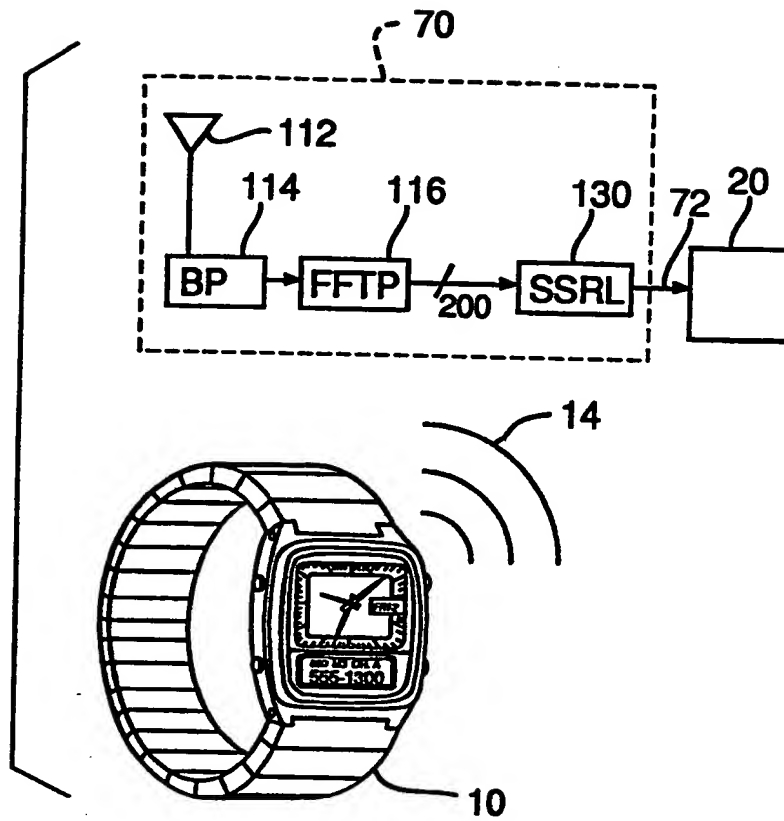
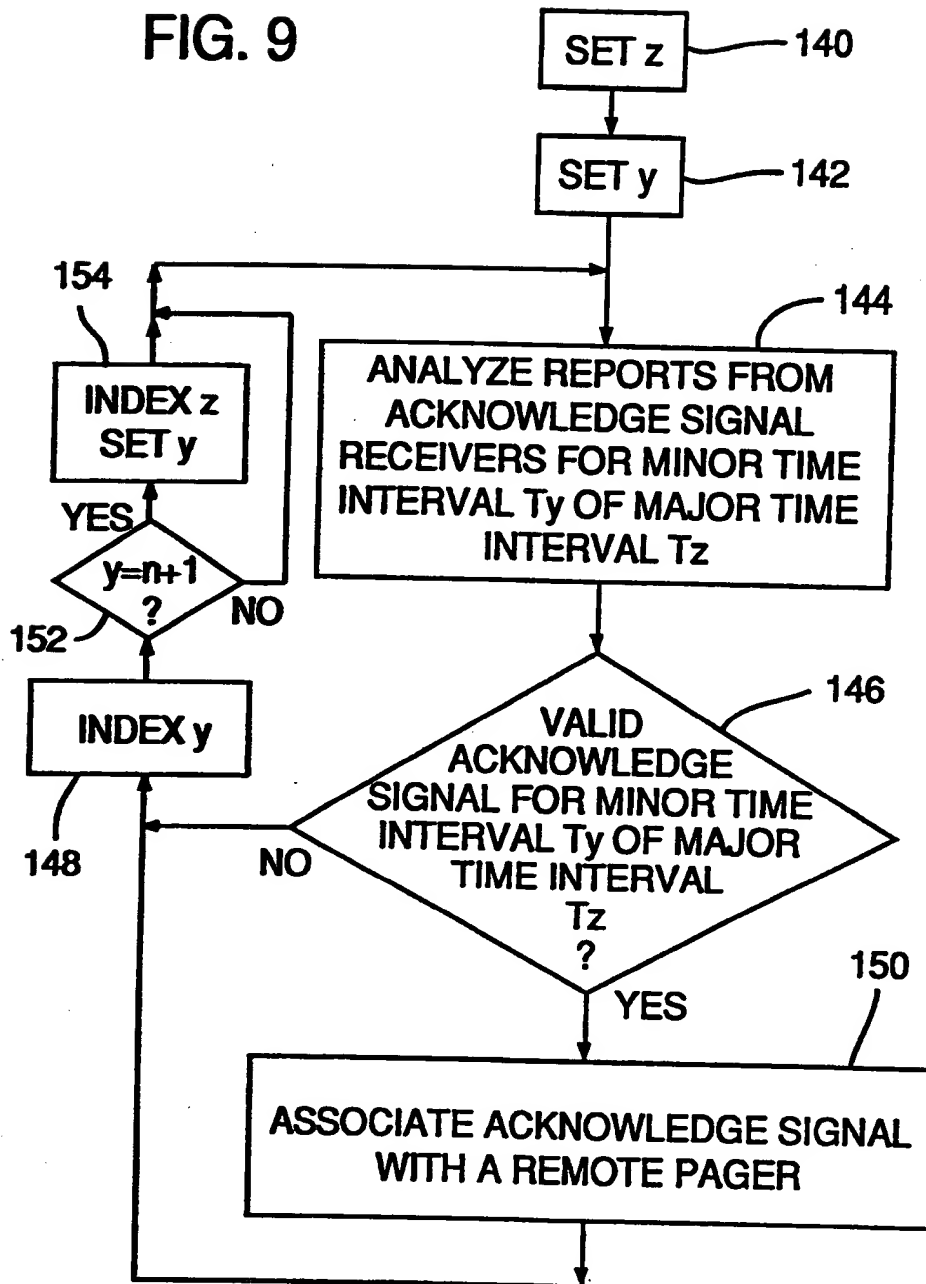


FIG. 8



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FIG. 9



INTERNATIONAL SEARCH REPORT

International Application No

PCT/US90/04141

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC(5): H04Q 7/00		
US Cl.: 340/825.44		
II. FIELDS SEARCHED		
Minimum Documentation Searched *		
Classification System :	Classification Symbols	
US	340/825.44, 825.49, 825.54, 311.1, 502, 504 371/32	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT **		
Category *	Citation of Document, ** with indication, where appropriate, of the relevant passages **	Relevant to Claim No. **
Y	US, A, 4,713,808 GASKILL ET AL., 15 DECEMBER 1987 See the entire document	1-13
Y	US, A, 4,604,618 AKIRA ET AL., 05 AUGUST 1986 See the entire document	1-13
Y	US, A, 4,646,082 ENGEL ET AL., 24 FEBRUARY 1987 See the entire document	7, 13
Y	US, A, 3,973,200 AKERBERG, 03 AUGUST 1976 See the entire document	1-13
Y	US, A, 3,668,640 DRISCOLL, 06 JUNE 1972 See the entire document	1-13
A	US, A, 4,754,262 HACKETT ET AL, 28 JUNE 1988 See the entire document	1-13
A P	US, A, 4,918,437 JASINAKI ET AL., 17 APRIL 1990 See the entire document	1-13
<p>* Special categories of cited documents: **</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"I" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international or priority date and not in conflict with the application to understand the principle or theory upon which the invention is based</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step if the document is combined with one or more other documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search *		Date of Mailing of this International Search Report *
01 OCTOBER 1990		07 JAN 1991
International Searching Authority *		Signature of Authorized Officer **
ISA/US		PETER WEISSMAN